

What is claimed is:

1. A plasma processing apparatus for performing a processing on a to-be-treated substrate mounted on a mounting table in a processing vessel by plasma of a processing gas, comprising:

a ring member formed of an insulating material and installed to surround the to-be-treated substrate on the mounting table;

10 one or more electrodes installed in the ring member; and

a DC power supply for applying a DC voltage to the one or more electrodes to adjust a plasma sheath region above the ring member.

15 2. The plasma processing apparatus of claim 1, further comprising a means for varying the applied voltage such that a first DC voltage is applied to the one or more electrodes when a first process is performed on the to-be-treated substrate and a second DC voltage is applied to the one or more electrodes when a second process is performed on the to-be-treated substrate.

25 3. The plasma processing apparatus of claim 2, wherein the first process is etching of a thin film and the second process is etching of another thin film which is different

from the thin film in the first process.

4. The plasma processing apparatus of claim 1, wherein  
the one or more electrodes in the ring member are installed  
5 along a diametrical direction and respective DC voltages  
applied to the one or more electrodes are adjusted  
independently.

5. A ring member in a plasma processing apparatus for  
10 performing a processing on a to-be-treated substrate mounted  
on a mounting table in a processing vessel by a plasma of a  
processing gas, wherein the ring member is formed of an  
insulating material and installed to surround the to-be-  
treated substrate on the mounting table, wherein the ring  
15 member comprises:

one or more electrodes, installed in the ring member,  
to each of which a DC voltage is applied to adjust a plasma  
sheath region above the ring member.

20 6. The ring member of claim 5, wherein a first DC voltage  
is applied to the one or more electrodes when a first  
process is performed on the to-be-treated substrate and a  
second DC voltage is applied to the one or more electrodes  
when a second process is performed on the to-be-treated  
25 substrate.

7. The ring member of claim 6, wherein the first process is etching of a thin film and the second process is etching of another thin film from which is different from the thin film in the first process.

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8. The ring member of claim 5, wherein the one or more electrodes in the ring member are installed along a diametrical direction and respective DC voltages applied to the one or more electrodes are adjusted independently.

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9 A plasma processing method, comprising the steps of:  
mounting a to-be-treated substrate on a mounting table  
in a processing vessel;

executing a first process on the to-be-treated  
15 substrate by generating plasma in a processing vessel under  
a condition in which a first DC voltage is applied to an  
electrode for adjusting a plasma sheath region, which is  
installed in a ring member formed of an insulating material  
and installed to surround the to-be-treated substrate on the  
20 mounting table; and

executing a second process on the to-be-treated  
substrate by generating plasma in the processing vessel  
under a condition in which a second DC voltage is applied to  
the electrode for adjusting the plasma sheath region.

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10. The ring member of claim 5, further comprising:

a base material; and  
a film formed by thermal spraying of ceramic on a surface of the base material,  
wherein the film is formed of ceramic including at 5 least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and at least a portion of the film is sealed by a resin.

11. The ring member of claim 5, further comprising:

10 a base material; and  
a film formed by thermal spraying of ceramic on a surface of the base material,  
wherein the film has a first ceramic layer formed of ceramic including at least one kind of element selected from 15 the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd and a second ceramic layer formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and at least a portion of at least one of the first and 20 the second ceramic layer is sealed by a resin.

12. The ring member of claim 10, wherein the resin is selected from the group consisting of SI, PTFE, PI, PAI, PEI, PBI and PFA.

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13. The ring member of claim 5, further comprising:

a base material; and

a film formed by thermal spraying of ceramic on a surface of the base material,

wherein the film is formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and at least a portion of the film is sealed by a sol-gel method.

14. The ring member of claim 5, further comprising:

10 a base material; and

a film formed by thermal spraying of ceramic on a surface of the base material,

wherein the film has a first ceramic layer formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and a second ceramic layer formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and at least a portion of at least one of the first and 20 the second ceramic layer is sealed by a sol-gel method.

15. The ring member of claim 13, wherein a sealing treatment is executed by using an element selected from elements in the Group 3a of the periodic table.

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16. The ring member of claim 10, wherein the ceramic is at

least one kind selected from the group consisting of  $B_4C$ ,  $MgO$ ,  $Al_2O_3$ ,  $SiC$ ,  $Si_3N_4$ ,  $SiO_2$ ,  $CaF_2$ ,  $Cr_2O_3$ ,  $Y_2O_3$ ,  $YF_3$ ,  $ZrO_2$ ,  $TaO_2$ ,  $CeO_2$ ,  $Ce_2O_3$ ,  $CeF_3$  and  $Nd_2O_3$ .

- 5       17. The ring member of claim 5, further comprising:  
          a base material; and  
          a film formed on a surface of the base material,  
          wherein the film has a main layer formed by thermal  
spraying of ceramic and a barrier coat layer formed of  
10      ceramic including an element selected from the group  
consisting of  $B$ ,  $Mg$ ,  $Al$ ,  $Si$ ,  $Ca$ ,  $Cr$ ,  $Y$ ,  $Zr$ ,  $Ta$ ,  $Ce$  and  $Nd$ .
- 15      18. The ring member of claim 17, wherein the barrier coat  
layer is formed of at least one kind of ceramic selected  
from the group consisting of  $B_4C$ ,  $MgO$ ,  $Al_2O_3$ ,  $SiC$ ,  $Si_3N_4$ ,  $SiO_2$ ,  
 $CaF_2$ ,  $Cr_2O_3$ ,  $Y_2O_3$ ,  $YF_3$ ,  $ZrO_2$ ,  $TaO_2$ ,  $CeO_2$ ,  $Ce_2O_3$ ,  $CeF_3$  and  $Nd_2O_3$ .
- 20      19. The ring member of claim 17, wherein the barrier coat  
layer is a thermally sprayed film at least a portion of  
which is sealed by a resin.
- 25      20. The ring member of claim 19, wherein the resin is  
selected from the group consisting of SI, PTFE, PI, PAI, PEI,  
PBI and PFA.
21. The ring member of claim 17, wherein the barrier coat

layer is a thermally sprayed film at least a portion of which is sealed by a sol-gel method.

22. The ring member of claim 21, wherein a sealing  
5 treatment is performed by using an element selected from elements in the Group 3a of the periodic table.

23. The ring member of claim 5, further comprising:

a base material; and

10 a film formed on a surface of the base material, wherein the film has a main layer formed by thermal spraying of ceramic and a barrier coat layer formed of engineering plastic formed between the base material and the main layer.

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24. The ring member of claim 23, wherein the engineering plastic is a plastic selected from the group consisting of PTFE, PI, PAI, PEI, PBI, PFA, PPS, and POM.

20 25. The ring member of claim 23, wherein the main layer is formed of at least one kind of ceramic selected from the group consisting of  $B_4C$ ,  $MgO$ ,  $Al_2O_3$ ,  $SiC$ ,  $Si_3N_4$ ,  $SiO_2$ ,  $CaF_2$ ,  $Cr_2O_3$ ,  $Y_2O_3$ ,  $YF_3$ ,  $ZrO_2$ ,  $TaO_2$ ,  $CeO_2$ ,  $Ce_2O_3$ ,  $CeF_3$  and  $Nd_2O_3$ .

25 26. The ring member of claim 5, further comprising:  
a base material; and

a film formed on a surface of the base material,  
wherein the film is formed of ceramic including at  
least one kind of element in the Group 3A of the periodic  
table and at least a portion of the film is hydrated by  
5 vapor or high temperature hot water.

27. The ring member of claim 5, further comprising:

a base material; and

10 a film formed on a surface of the base material,  
wherein the film has a first ceramic layer formed of  
ceramic including at least one kind of element in the Group  
3a of the periodic table and a second ceramic layer formed  
of ceramic including at least one kind of element in the  
Group 3a of the periodic table, and at least a portion of at  
15 least one of the first and the second ceramic layers is  
hydrated by vapor or high temperature hot water.

28. The ring member of claim 26, wherein the film is a  
thermally sprayed film formed by thermal spraying or a thin  
20 film formed by a thin film formation technique.

29. The ring member of claim 26, wherein the film is  
formed of ceramic selected from  $\text{Y}_2\text{O}_3$ ,  $\text{CeO}_2$ ,  $\text{Ce}_2\text{O}_3$  and  $\text{Nd}_2\text{O}_3$ .

25 30. The ring member of claim 5, further comprising:  
a base material; and

a film formed on a surface of the base material,  
wherein the film has a first ceramic layer formed of  
ceramic including at least one kind of element in the Group  
5 3a of the periodic table and a second ceramic layer formed  
by thermal spraying of ceramic, and at least a portion of  
the first ceramic layer is hydrated by vapor or high  
temperature hot water.

31. The ring member of claim 30, wherein the first ceramic  
10 layer is a thermally sprayed film formed by thermal spraying  
or a thin film formed by a thin film formation technique.

32. The ring member of claim 30, wherein the first ceramic  
layer is formed of ceramic selected from the group  
15 consisting of  $\text{Y}_2\text{O}_3$ ,  $\text{CeO}_2$ ,  $\text{Ce}_2\text{O}_3$  and  $\text{Nd}_2\text{O}_3$ .

33. The ring member of claim 30, wherein the second  
ceramic layer is formed of at least one kind of ceramic  
selected from the group consisting of  $\text{B}_4\text{C}$ ,  $\text{MgO}$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{SiC}$ ,  
20  $\text{Si}_3\text{N}_4$ ,  $\text{SiO}_2$ ,  $\text{CaF}_2$ ,  $\text{Cr}_2\text{O}_3$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{YF}_3$ ,  $\text{ZrO}_2$ ,  $\text{TaO}_2$ ,  $\text{CeO}_2$ ,  $\text{Ce}_2\text{O}_3$ ,  
 $\text{CeF}_3$  and  $\text{Nd}_2\text{O}_3$ .

34. The ring member of claim 5, further comprising:  
a base material; and  
25 a film formed on a surface of the base material,  
wherein the film has a hydroxide layer formed of

hydroxide including at least one kind of element in the Group 3a of the periodic table.

35. The ring member of claim 34, wherein the hydroxide  
5 layer is a thermally sprayed film formed by thermal spraying  
or a thin film formed by a thin film formation technique.

36. The ring member of claim 34, wherein the hydroxide  
layer is formed of hydroxide selected from  $\text{Y(OH)}_3$ ,  $\text{Ce(OH)}_3$   
10 and  $\text{Nd(OH)}_3$ .

37. The ring member of claim 34, wherein at least a portion of the hydroxide layer is sealed.

15 38. The ring member of claim 10, further comprising an anodic oxidized film formed between the base material and the film.

20 39. The ring member of claim 38, wherein the anodic oxidized film is sealed by an aqueous solution of metal salt.

40. The ring member of claim 38, wherein the anodic oxidized film is sealed by a resin selected from the group consisting of SI, PTFE, PI, PAI, PEI, PBI and PFA.

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41. The ring member of claim 5, wherein the ring member is

formed of a sintered ceramic body including at least one kind of element in the Group 3a of the periodic table, and at least a portion of the sintered ceramic body is hydrated by vapor or high temperature hot water.

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42. The ring member of claim 41, wherein the sintered ceramic body is formed by hydrating ceramic selected from the group consisting of  $\text{Y}_2\text{O}_3$ ,  $\text{CeO}_2$ ,  $\text{Ce}_2\text{O}_3$  and  $\text{Nd}_2\text{O}_3$ .

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43. The ring member of claim 5, wherein the ring member is formed of a sintered ceramic body including a hydroxide having at least one kind of element in the Group 3a of the periodic table.

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44. The ring member of claim 43, wherein the hydroxide included in the sintered ceramic body is selected from the group consisting of  $\text{Y(OH)}_3$ ,  $\text{Ce(OH)}_3$  and  $\text{Nd(OH)}_3$ .